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VOICE-RELATED CHANGES IN PEOPLE WITH PARKINSON'S DISEASE AFTER A GROUP SINGING INTERVENTION

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Parkinsonin tauti on etenevä neurologinen sairaus, jota sairastaa noin 1 % yli 50-vuotiaista. Suomessa on tällä hetkellä noin 13 000–14 000 Parkinsonin tautia sairastavaa henkilöä, ja määrän odotetaan yhä kasvavan väestön ikääntyessä. Parkinsonin tauti voi aiheuttaa sairastuneelle huomattavaa haittaa. Sen pääoireita ovat vapina, lihasjäykkyys ja liikkeiden hidastuminen, mutta siihen liittyy useimmiten myös kommunikaatiokyvyn heikkenemistä hypokineettisestä dysartriasta eli taudille tyypillisistä ääni- ja puheoireista (hiljainen puheääni, äänen monotonisuus, artikulaation epäselvyys) johtuen. Näitä oireita on taudin etenevästä luonteesta huolimatta mahdollista helpottaa kuntoutuksen keinoin, mikä lieventää niistä usein aiheutuvaa psykososiaalista haittaa. Rajallisista puheterapiaresursseista johtuen puheterapeuttista kuntoutusta on kuitenkin saatavilla vaihtelevasti. Tässä pro gradu -tutkielmassa selvitetään alustavasti, olisiko Parkinsonin taudin äänioireisiin apua ryhmämuotoisista laulullisista menetelmistä niin, että niitä voitaisiin käyttää kuntoutuksessa puhe- ja ääniterapian täydentäjänä.

Tämä tutkielma on osa Tampereen yliopiston monitieteistä Kuuluva ääni -hanketta, jossa pyritään hankkimaan lisätietoa Parkinsonin taudin ääni- ja kommunikaatiokuntoutusta koskien. Hankkeeseen kuuluvan laulullisen kuntoutuksen kävi kokonaisuudessaan 16 satunnaisesti valittua, Parkinsonin tautia sairastavaa osallistujaa. Ryhmällä oli kahdeksan 90-minuuttista tapaamista. Tapaamiskerrat noudattelivat kuoro-harjoitusten rakennetta, mutta harjoittelussa painotettiin puheterapeuttisten menetelmien (vrt. Lee Silverman Voice Treatment) kanssa yhteneviä tavoitteita. Kotiharjoittelun tueksi osallistujat saivat kirjalliset ohjeet ja harjoitus-CD:n.

Osallistujilta tallennettiin luenta- ja ääntönäytteet ennen ja jälkeen intervention. Tallenteista analysoitiin äänenpainetaso (SPL), perusäänentaajuus hajontoineen (F_0, F_0 SD) sekä maksimaalinen äännönkesto (MPT). Lisäksi osallistujat täyttivät lyhennetyn Voice Handicap Index -kyselyn (VHI). Intervention jälkeen havaittiin tilastollisesti merkitsevä muutos osallistujien VHI-pisteissä, luennan SPL:ssä, pitkän /a/-äännön SPL:ssä sekä maksimaalisessa äännönkestossa. Äänihäiriön aiheuttama haitta siis lieveni, äänen voimakkuus kasvoi ja äännönkesto piteni. Merkitsevää muutosta äänen monotonisuudessa (F_0, F_0 SD) ei tullut esiin.

Tutkimuksen tulokset viittaavat siihen, että laulullisten menetelmien soveltaminen saattaisi olla hyödyllinen lisä Parkinson-potilaiden äänikuntoutukseen. Koska tässä tutkittiin vain intervention jälkeisiä muutoksia eikä menetelmän vaikuttavuutta, lisätutkimus kontrolliryhmä-asetelmalla olisi tarpeen. Lisäksi terveiden ikääntyneiden vastaava suoriutuminen olisi hyvä kartoittaa viitearvojen saamiseksi. On myös huomattava, että koska osallistujat valikoituivat tutkimukseen pitkälti oman aktiivisuutensa perusteella, ryhmä ei välttämättä edustanut kattavasti kaikkia Parkinsonin tautia sairastavia. Nähtäväksi jää, yleistyvätkö äänisidonnaiset muutokset osallistujien arkeen ja kuinka pitkäaikaisiksi ne jäävät. Tästä saataneen lisätietoa 6 kk ja 12 kk intervention jälkeen tehtävissä seurantamittauksissa, joskin taudin etenevä luonne todennäköisesti rajoittaa tulosten yksiselitteistä tulkintaa.

Avainsanat: puheterapia, ääniterapia, Parkinsonin tauti, hypokineettinen dysartria, äänihäiriö, kuntoutus, ryhmäkuntoutus, laulu, kuoro

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1 INTRODUCTION

Parkinson's disease (PD) is a slowly progressive, neurodegenerative disorder of unknown etiology, associated with dopamine depletion in the basal ganglia (Duffy, 2005, p. 190; Lezak, Howieson, Bigler & Tranel, 2012, p. 271). Gradually, the progress of the disease causes severe impairment and disability (von Campenhausen et al., 2005). The main motor symptoms of PD are tremor, bradykinesia and rigidity (Lezak et al., 2012, pp. 271–272). After symptoms appear, usually in mid to late life, survival is approximately nine years (Duffy, 2005. p. 190). Idiopathic PD is relatively common, with 1% of the population over the age of 50 exhibiting it, men and women alike (Yorkston, Miller & Strand, 2004, p. 86). According to a fairly recent literary search, the prevalence of the disease in Europe is between 5/100,000 and 26/100,000 (von Campenhausen et al., 2005). In Finland, there are currently approximately 13,000–14,000 people with PD, a slight majority of them male (Kaakkola & Marttila, 2015).

In Finland, like in many other Western countries, the demographics will undergo a change in the coming years as the population ages: by the year 2030 the percentage of people over 65 years of age will be approximately 26% and by the year 2060 approximately 29% (Official Statistics of Finland, OSF, 2015). This means that the number of people suffering from diseases typical of advanced age will, most likely, also increase considerably. In addition, it has to be taken into account that at least one third of all patients diagnosed with PD are under 65 years of age (Martikainen, Luukkaala & Marttila, 2007). Therefore, a significant number of those affected by the disease are in fact of working age.

According to Miller et al. (2008), PD has a negative influence on communication, irrespective of age and gender and almost without exception. Conversation and other everyday activities can become very difficult even when voice or speech changes are so mild the speakers with PD sound intelligible to listeners (Miller, Noble, Jones & Burn, 2006). Willingness to participate in social interaction is also affected by fatigue typical of the disease, among other things (Schalling, Johansson & Hartelius, 2018). Problems in interaction can directly influence a person's social life to such an extent that some people with PD start to avoid contact with others altogether (Miller et al., 2006).

In many regions in Finland, speech therapy is not readily available to adults due to a lack of resources. Therefore, finding more effective ways of using the resources and creating more intervention options both for service providers and patients is of general interest. Rehabilitation offered to people with PD is traditionally of individual and speaker-oriented basis (Duffy, 2005, p. 465), and the methods that

are typically used to treat voice problems associated with PD (e.g. LSVT, Speak out!) are especially demanding resource-wise: intensive as well as individual.

According to a number of speech-language therapists working with people with Parkinson's disease in Southern Finland (personal communications, November 2018), group therapy sessions are already offered in many areas. The contents of these group sessions are created locally and the emphasis is often on voice production. Research is needed to determine effective methods that might be used on a general basis, perhaps even increasing the group size to ensure better availability. One such group therapy approach targeted to treat voice problems could be the kind of group singing intervention investigated here. So far, only a limited quantity of research has been conducted on the possible health-related benefits of singing in Parkinson's disease, but some encouraging results have been reported across a wide range of speech and voice features (Barnish, Atkinson, Barran & Barnish, 2016, review). In addition to improving speech and voice, group singing has the potential of improving communication in general and willingness to participate, the lack of which is a common complaint among this population (Miller et al., 2006; Schalling et al., 2018). Therapeutic singing has the potential to increase the participants' psychosocial well-being in many ways. Participants have regarded their involvement in singing groups as beneficial, fun, and engaging, and have appreciated especially the peer support provided by other people with Parkinson's disease (Stegemöller et al., 2017).

1.1 Typical voice-related symptoms in Parkinson's disease

1.1.1 Hypokinetic dysarthria

Speech and voice symptoms are common in Parkinson's disease. According to information gathered during assessments and from self-reports, 70% to 90% of people with PD suffer from them (Theodoros, 2011). In a study conducted by Logeman et al. in the late 1970s (as cited in Duffy, 2005, p. 196), for example, approximately 90% of 200 people with PD had speech impairments. The speech and voice disturbances associated with Parkinson's disease are often referred to as *hypokinetic dysarthria*. Hypokinetic dysarthria has a strong association with basal ganglia control circuit pathology, probably bilateral, and also with an insufficiency of the neurotransmitter dopamine (Duffy, 2000, p. 46; Duffy, 2005, p. 187). Many deviant speech characteristics are assumed to be due to rigidity, slow repetitive movements, and reduced force and range of movement associated with the respiratory, laryngeal, velopharyngeal, and articulatory components of speech production (Duffy,

2000, p. 46). One symptom of the reduced respiratory and laryngeal movement is a reduced maximum phonation time (MPT, longest possible vowel /a/ at a comfortable pitch and loudness), which has been found to be significantly shorter for people with PD compared to control groups (Savic, Djuric & Buzadzija, 2016). In addition to voice dysfunction, hypokinetic dysarthria often comprises of symptoms such as imprecise sounds, indistinct words and accelerated speech due to weaker articulatory contacts caused by hypokinetic movements and difficulties of alternating rapid movements (Miller, 2017, review). It has been speculated that parkinsonian speakers might have difficulty switching from one motor programme to another much the same way that they have difficulties controlling their limbs (Ackermann & Ziegler, 1991; Yorkston et al., 2004, p. 100).

Miller et al. (2007) found in their study that speech intelligibility was reduced in 69.6% of people with PD compared to a control group, and of those with changes in intelligibility, 38% reported that their speech difficulty was one of their top concerns. In the 1970s study by Logeman et al. (as cited in Duffy, 2005, p. 196), 45% of the respondents had only voice abnormalities, but everyone suffering from articulation problems also had voice problems. This could indicate that dysarthria has a tendency to begin with laryngeal manifestations, namely voice impairments. According to Darley et al. (as cited in Yorkston et al., 2004, p. 102), the vocal folds remain structurally normal, but changes in pitch, loudness and voice quality can often be perceived. If the vocal folds are very stiff, as is often the case in hypokinetic dysarthria, they cease to vibrate normally (Buder, 2006, p. 130).

The dysarthria progresses slowly throughout the course of the disease (Theodoros, 2011). The onset varies, and it is not consistently related to the severity of the disease. Generally speaking, however, it seems that the more incapacitating the disease becomes, the more severe the dysfunction (Holmes, Oates, Phyland & Hughes, 2000). Because voice changes usually emerge before impairments in other speech systems, dysphonia can in fact be the first and the most debilitating speech impairment in people with PD and hypokinetic dysarthria (Duffy, 2005, p. 197; Yorkston et al., 2004, p. 103). As the dysarthria progresses, new voice impairments, such as vocal tremor, may also occur (Holmes et al., 2000). Darley, Aronson and Brown (as cited in Duffy, 2005, p. 196) have listed the most deviant speech dimensions associated with hypokinetic dysarthria in order of severity: monopitch is the most severe symptom, reduced stress the second most severe, and monoloudness the third most severe.

1.1.2 Reduced vocal loudness

Reduced vocal loudness is a typical symptom in Parkinson's disease (Duffy, 2000, p. 46; Fox & Ramig, 1997; Schalling et al., 2018). It is also a very debilitating symptom, because it impacts the ability to communicate against background noise in a variety of everyday situations (Theodoros, 2011). In a recent Swedish study, weak voice was reported by 71% of the respondents, which made it the most common speech and voice symptom connected with PD (Schalling et al., 2018). Similar conclusions of the prevalence of reduced vocal loudness have also been reached by others (Duffy, 2000, p. 46; Fox & Ramig, 1997). A study conducted by Ho et al. (1998) showed that the gradual deterioration of the participants' speech features almost always affected the voice first – an initial problem with voice quality progressed to a reduction in speech volume. In fact, reduced vocal loudness is such a prominent symptom that it may make family and friends suspect something is wrong even before diagnosis is sought (Miller, 2017), and it can also deteriorate further as the disease progresses and can become quite severe in some cases (Ho, Iansek, Marigliani, Bradshaw & Gates, 1998; Holmes et al., 2000). In spite of this, not all people with PD are found to suffer from reduced loudness, which may be due to the stage of the disease or their ability to speak louder than normal in the context of the assessment – the laboratory or speech clinic are unnatural clinical settings when compared with actual activities of daily living (Adams & Dykstra, 2009, p. 168).

The underlying pathophysiology of reduced loudness (also referred to as hypophonia, low speech intensity, or monoloudness) is the reduced range of movement of thoracic, laryngeal and pharyngeal musculature (Duffy, 2005, p. 196; Miller, 2017; Moon, Adams & Jog, 2006; Yorkston et al., 2004, p. 100) resulting in a phonatory-respiratory-prosodic deficit (Duffy, 2005, p. 196). The respiratory driving pressure is decreased, as is the vocal fold closure, which prevents the production of an acoustically strong, loud voice (Hammer & Barlow, 2010). The voice mechanism of people with PD as such is not impaired, however – what is impaired is their self-monitoring, resulting in reduced awareness of voice intensity (Miller, 2017).

Because of the impaired self-monitoring or somatosensory function, individuals with PD are often unaware of the extent of their voice deficits and may feel as though they are shouting and using great physical effort when speaking with normal loudness – in other words, they consistently overestimate their speech and oral reading loudness (Hammer & Barlow, 2010; Ho, Bradshaw & Iansek, 2000). The pattern of intensity regulation is in fact normal, but it has an overall intensity reduction compared with healthy controls, which is analogous to the reduced range of limb movement found in PD (Moon, Adams & Jog, 2006). It is also thought that people with PD have an abnormal perception of both

external and self-generated speech intensity stimuli (Clark et al., 2014). The mechanisms behind these sensory impairments remain unclear, but researchers have suggested links to abnormal sensory filtering associated with basal ganglia dysfunction and the influence of a motor-sensory inhibitory mechanism on auditory cortical activity during vocalisation (Theodoros, 2011). The sensory impairments can be overridden with explicit external cuing, but only short-term (Sapir, Ramig & Fox., 2011).

Loudness as such is a relative, perceptual concept not readily available for comparison (Baken & Orlikoff, 2000, p. 94). Acoustically, the reduced loudness may be perceived as a reduced vocal sound pressure level (SPL, dB) in all types of speech and voice tasks (Fox & Ramig, 1997), with spontaneous, conversational speech being the most affected (Moon, Adams & Jog, 2006). Fox and Ramig (1997) found that there was a statistically significant group difference in vocal SPL between persons with PD and their healthy comparisons: measured at 30 cm, the SPL of people with Parkinson's disease was, on average, 2–4 dB lower, which corresponds to a 40% loudness reduction perceptually. The greatest difference in vocal SPL between subjects of the two groups was observed on the maximum sustained vowel phonation task. Adams et al. (2005) obtained similar results in their study, in which subjects were asked to repeat a sentence over varying levels of background noise. The SPL of PD subjects was approximately 2–3 dB lower than that of healthy controls across all noise levels. This study also showed, however, that PD subjects, like their controls, increase their speech intensity systematically according to rising background noise levels, which indicates that they are indeed physically capable of producing louder voice. Ho et al. (1999), on the other hand, found that subjects with PD, apart from demonstrating decreased speech loudness overall, were less able than their healthy controls of increasing loudness according to the increase of background noise and of decreasing it according to instantaneous auditory feedback. Their vocal intensity was over-constant, in other words lacking of modulation. The subjects with PD only achieved normal volume regulation when they were given explicit verbal instructions to increase their speaking volume. More recently, the SPL of people with PD over background noise has been found to be even lower – approximately 5 dB less than that of their controls (Dykstra, Adams & Jog, 2012).

A 40% change in perceptual loudness is likely to affect the intelligibility of a person's speech (Fox & Ramig, 1997). People with PD often assume others have hearing loss when they are not understood, which is due to the impaired perception of their own speech and voice abilities. This has been further supported by spouse ratings, which have been higher than the PD participants' own assessments of the severity of their voice deficits (Hammer & Barlow, 2010). The average increases in SPL achieved in rehabilitation (LSVT LOUD, both individual and group based) have been approximately 6 dB and

thus perceptibly audible (Ramig, Sapir, Fox & Countryman, 2001; Searl et al., 2011). It has to be taken into account, however, that reduced loudness is not the only factor affecting intelligibility – also monopitch can decrease a person's chances of being understood correctly (Bunton, Kent, Kent & Duffy, 2001).

1.1.3 Monotony of pitch

Reduced pitch variation or monopitch is common in Parkinson's disease (Duffy, 2000, p. 46). In a recent study, monotone voice was the fourth most common voice symptom after weak voice, strained-strangled voice and harsh voice (Schalling et al., 2018). Normal speech is not monotonous: there is a range of fundamental frequencies indicating word and sentence stress, statement form and affective content (Baken & Orlikoff, 2000, p. 170). The speech of people with PD is often disrupted by a marked dysprosody, meaning that the stress and intonation patterns are altered (Miller, 2017). The intonation patterns of utterances disappear and speech is produced on a single note, which often leads to misinterpretations (Duffy, 2005, p. 196). Limited pitch variability can be present already in the early stage of PD and usually worsens gradually over the course of the disease (Holmes et al., 2000). The reduction of pitch variation is so common and so marked in patients with PD that it is in fact a good indicator of parkinsonian speech and a potential diagnostic marker (Theodoros, 2011).

Acoustically, the way speakers use their voice is reflected by the speaking fundamental frequency (F_0) and standard deviation of the F_0 (Baken & Orlikoff, 2000, p. 185). The average speaking F_0 shows the typical pitch, and standard deviation of the F_0 indicates pitch variability (Laukkanen & Leino, 1999, pp. 159–160). Therefore, monopitch means that there is a lack of fundamental frequency (F_0) variability across an utterance (Bunton et al., 2001). Standard deviation (SD) has been considered a better approach to the description of variability than an examination of F_0 range, for example, and is quite widely used as index of F_0 variability (Baken & Orlikoff, 2000, p. 170). Analysis of F_0 variation strongly supports the perception of monopitch (Theodoros, 2011). For analysis purposes, reading a passage can be considered a more reliable vocal task than spontaneous speech because it enables both intrapersonal and interpersonal comparisons, even though reading style and reading abilities can affect the outcome (Baken & Orlikoff, 2000, p. 172).

The lowest possible F_0 of parkinsonian patients has been found to be higher than that of healthy controls (Baken & Orlikoff, 2000, pp. 187–189). This makes the maximum phonational frequency range (MPFR) more limited than usual, even when the highest possible F_0 remains unaffected. The

inability to produce lower notes is caused by the elevated muscle tone typical of PD. According to Bunton et al. (2001), monopitch has been found to affect sentence-level intelligibility of neurologically normal speech as well as speakers whose articulatory precision is compromised due to dysarthria. It seems that syllable contrast resulting from even minor F_0 variations is an important perceptual cue and thus crucial intelligibility-wise.

Monopitch, like reduced loudness, results from the reduced range of movement in Parkinson's disease (Yorkston et al., 2004, p. 100). A major part of the dysprosody in PD, however, is a more generalised higher-level impairment of understanding and producing appropriate prosody (Miller, 2017). Since people with PD have difficulty in appreciating the prosodic tones used by others, they often find it hard to distinguish and differentiate emotions. Also, because of the monotone voice combined with hypomimia and reduced arm movements, people with PD can face negative social interpretations of themselves and can therefore be considered more negative and less socially desirable than their healthy peers (Miller, 2017; Schwartz & Pell, 2017; Tickle-Degnen & Lyons, 2004). All these features combined can make social interaction more challenging.

1.2 Challenges in social interaction

1.2.1 Changes affecting communication

Parkinson's disease has a negative influence on communication, irrespective of age and gender and almost without exception (Miller et al., 2008). Consequently, conversation and other everyday activities can become very difficult – even when voice or speech changes are so mild that the speakers sound intelligible to others (Miller et al., 2006). The ability to communicate can indeed be influenced by the disease even before apparent alterations to intelligibility or motor status occur (Miller et al., 2008). People with Parkinson's disease often recognize the deteriorating impact of the disease on their communication, although this self-perceived impact does not necessarily bear relation to other measures of speech, demographics or disease severity.

Parkinson's disease affects communication noticeably through voice and speech, but there are also other interaction-related changes typical of the condition. In a recent Swedish survey, most participants reported both speech and language symptoms, even at quite an early stage of the disease, and many of them experienced restrictions in their communicative participation (Schalling et al., 2018). In addition to the speech and language symptoms, communication can also be affected by

depression and cognitive changes, which are commonly linked to Parkinson's disease (Yorkston et al., 2004, p. 95). Indeed, depression is one of the consistent features of PD and its occurrence has been estimated to be in the 40% to 60% range, or even higher (Lezak et al., 2012, p. 278). The prevalence of major depression in PD is approximately 23% (Goodarzi et al., 2016). As for dementia, it has been estimated that 24–31% of people with PD develop Parkinson disease dementia (Aarsland, Zaccai & Brayne, 2005). According to Lieberman (as cited in Lezak et al., 2012, p. 278), an additional 20% may show signs of cognitive impairment without frank dementia. However, it is noteworthy that even without dementia, the high-level language production can be impaired in PD (Altmann & Troche, 2011). Successful communication requires the support of many other cognitive functions apart from language-specific processing, such as executive functioning, attentional focus and working memory (Miller, 2017).

Communication can be noticeably affected by the aforementioned changes in cognitive, linguistic and pragmatic abilities, and these changes have an effect on both language production and comprehension (Holtgraves, 2016, review). It is rather common for people with Parkinson's disease to report such linguistic difficulties as word-finding problems, getting off topic in conversation, and problems expressing their thoughts clearly (Miller, 2017; Schalling et al., 2018). It has also been noted that people with PD produce less information content and less complex sentences, and their grammaticality and fluency can also become impaired (Altmann & Troche, 2011). The problems in language comprehension can manifest themselves in many ways as well, for example as difficulties to follow subtle shifts of topic in conversation, to understand non-literal meanings (e.g. metaphors and irony), or to recognise speakers' intentions (Holtgraves, 2016). In Parkinson's disease, pragmatics can indeed become impaired both on verbal and non-verbal level. In addition to linguistic challenges, the altered facial, arm and body posture signals can make it more difficult to engage in a conversation (Miller, 2017). People with PD also interpret the facial expressions and prosodic cues of their conversation partners less accurately (Gray & Tickle-Degnen, 2010). Because of all this, misinterpretations can occur, and it is not rare for people with PD to be interpreted, for example, as depressed, uninterested or tired (Miller, 2017). Many of the communication difficulties worsen as the disease progresses but, at the same time, not all people with PD display these communication-related deficits (Holtgraves, 2016). It is also noteworthy that since people with PD may not be fully aware of their deficits, awareness and sensitivity is required from people communicating with them.

1.2.2 Psychosocial consequences

Although the ability to communicate is vital for daily living, it is also very closely linked to how we feel about ourselves and how other people react to us (Miller, 2017). In PD, the mere act of speaking turns into an effort-demanding activity – physically as well as cognitively and emotionally – and the social context of speaking gains more relevance as the value of participating is weighed against the effort required for communication (Yorkston, Baylor & Britton, 2017). A person's willingness to participate in social interaction can be affected by fatigue alone, which is a very common self-perceived problem present already in the early stages of PD (Schalling et al., 2018). Speaking can also evoke negative emotions such as frustration and embarrassment, which can further hinder communicative participation (Yorkston et al., 2017). Indeed, feelings of embarrassment caused by speech are familiar to the majority of people with PD-related communication changes (Schalling et al., 2018). As a result, new strategies for communication can emerge and people with Parkinson's disease can start to, for example, avoid difficult situations, modify their way of speaking, or talk as little as possible. Problems in interaction can directly influence a person's social life to such an extent that some people start to avoid contact with others altogether (Miller et al., 2006). Fortunately, attention has been drawn increasingly to the psychosocial consequences of Parkinson's disease and other similar conditions since the adoption of the World Health Organization's (2001) International Classification of Functioning, Disability and Health (Yorkston et al., 2017). Nevertheless, participation restrictions, such as problems in psychosocial functioning, are still among the least investigated features affecting the health-related quality of life (HRQoL) of people with PD (van Uem et al., 2016).

In light of the current literature, it seems, however, that psychosocial functioning deficits that result in participation restrictions have the strongest negative effect on the health-related quality of life (HRQoL) of people with PD (van Uem et al., 2016). This means that many non-motor, psychological features, such as depression and fear, affect the HRQoL of people with PD much more than motor symptoms like bradykinesia and tremor. In support of this view, it appears that people with PD are often not that concerned about the changes affecting their speech and voice as such (Miller et al., 2006; van Uem et al., 2016). What is very concerning to them is the impact of these changes on their self-concept, family dynamics, and their ability to participate in everyday activities (Miller et al., 2006). Unfortunately, this negative impact can go untreated, especially if the person does not present perceivable changes in speech intelligibility or speech is not their primary concern. Therefore, an early referral for speech and language assessment extending to psychosocial impact is crucial even

before changes in voice and speech are obvious, in order to try to prevent the person from developing loss of control and confidence (Miller et al., 2008). In fact, focusing more on the psychosocial aspects of communication and the cognitive demands of speaking has been suggested as an improvement, so that better speech treatment could be provided for people with PD (Yorkston et al., 2017).

1.3 Speech-language therapy in Parkinson's disease

1.3.1 Principles of rehabilitation

Rehabilitation is key in maintaining the speech and voice functions in Parkinson's disease as intact as possible for as long as possible. While it is true that some patients benefit from dopaminergic medication, the effects can fluctuate according to the drug cycle, and, generally speaking, speech and voice disorders related to PD do not respond to medical interventions very well (Duffy, 2005, p. 489; Holtgraves, 2016; Schulz, 2011). Treating speech and voice disorders in degenerative neurological diseases can be challenging due to the progressive nature of the disease, but effective and scientifically proven methods for rehabilitation, such as the Lee Silverman Voice Treatment, are available (Ramig, Halpern, Spielman, Fox & Freeman, 2018; Sapir et al., 2011). When it comes to voice rehabilitation, the same clinical goals that apply to organic voice disorders should also guide the treatment of the hypo adduction associated with PD (Buder, 2006, p. 135).

Speech therapy for people with PD is usually speaker-oriented and individual by nature (Duffy, 2005, p. 465). It can be broad-based (targeting voice loudness, intonation and articulation) or focus on a single aspect of speech production, such as phonation (Yorkston et al., 2004, p. 106). Recognising and addressing sensory processing deficits, such as the misperception of vocal loudness related to idiopathic PD, is also important (Fox, Morrison, Ramig, & Sapir, 2002), as are the psychosocial aspects discussed in the previous chapter. As well as targeting the impairment, therapy work should concentrate on maintaining and re-establishing control and independence (Miller et al., 2008).

Treatment is more likely to be effective if it is theoretically driven, empirically based, and follows the principles of neural plasticity (Sapir et al., 2011). In motor plasticity, repeated performance changes cortical organisation, which in turn improves motor performance (Duffy, 2005, p. 445). Key elements for achieving this are specificity, repetition, intensity and timing (Kleim & Jones, 2008). It has also been suggested that treatment is more effective in the earlier stages of PD, so it is crucial that clinicians address the early symptoms, such as monopitch, monoloudness and breathy voice (Holmes

et al., 2000). Early intervention is recommended also from the psychosocial point of view, as stated earlier: if communication changes such as speech alterations become severe, feelings of lost control and confidence begin to hinder improvements otherwise approachable in rehabilitation (Miller et al., 2008).

1.3.2 Voice rehabilitation: Lee Silverman Voice Treatment

While voice impairments related to neurological diseases can be approached in many ways, the most studied method of voice therapy connected with PD that has proven to be effective is the Lee Silverman Voice Treatment (LSVT LOUD) introduced in 1994 by Dr. Lorraine Ramig and her colleagues. The method concentrates on loud voice production. People with PD are capable of speaking more loudly when instructed to do so, but they are dependent of external cuing (Sapir et al., 2011). Therefore, the aim of the treatment is to help people with PD regain their self-regulatory internal cuing through a recalibration of motor and perceptual systems. LSVT LOUD trains increased vocal loudness concentrating on agonist muscle activation – the loud phonation is achieved by amplifying the respiratory, laryngeal and orofacial muscle activity simultaneously.

LSVT LOUD is a standardised, research-based and neuroplasticity-principled method, and the intensive treatment period (four weeks with four individual clinical sessions per week plus high-effort home exercises) is delivered by an LSVT certified speech therapist (Ramig et al., 2018; Sapir et al., 2011; What is LSVT LOUD?, 2018). In spite of targeting voice, LSVT LOUD may be beneficial for speech in general. Fox et al. (2002) have proposed that by targeting vocal loudness, motor patterns for speech may also be triggered. Intensive loudness training may therefore stimulate the activation and modulation of other speech motor programmes, improving speech overall.

According to a Cochrane review (Herd, Tomlinson, Deane et al., 2012b) that covered three LSVT studies and a total of 41 patients, using the LSVT method increased SPL by an average of 7–18%, which is clinically relevant. The amplification was apparent also after 6 months, although it had at that point decreased somewhat. In another review (Herd, Tomlinson, Deane et al., 2012a) it is stated that LSVT LOUD improved the SPL in a reading test on average 5.5 dB more than respiration therapy. However, it is inconclusive whether the results achieved with LSVT LOUD – while evident in training and testing settings – generalise to the activities of daily living (Herd, Tomlinson, Deane et al., 2012b). In addition, because of its highly intensive nature, LSVT LOUD requires a great deal from the health care provider: the individual has to be offered four weekly sessions for four

consecutive weeks. Adaptations to the standard LSVT procedure have therefore been suggested. In a case study by Rantala, Siikanen, Kankare and Kukkonen (2013), for example, the sessions were delivered three times per week for six consecutive weeks, divided between three different therapists. The SPL of the participant increased despite the modified number of weekly sessions.

Online LSVT LOUD is available at places (Herd, Tomlinson, Deane et al., 2012a; personal communications, November 2018), and can be of help in cases where attending therapy is hindered by distance or the mobility issues common in PD (Theodoros, 2011). In addition, group adaptations have been studied (Manor et al., 2005; Searl et al., 2011).

1.3.3 Availability of speech-language therapy for individuals with Parkinson's disease

The percentage of Finnish people with PD who receive speech therapy has not been surveyed thus far (Simberg, 2015). Elsewhere in Europe, some availability studies have been conducted. In a recent Swedish survey, for example, 42% of the respondents reported having received speech-language pathology treatment, with voice training being the most common focus (Schalling et al., 2018). In the UK, the figure has been lower than 40% (Miller, Deane, Jones, Noble & Gibb, 2011). Internationally, the percentage has been estimated to be as low as 3–4% (Trail et al., 2005). It is not clear how well medical doctors, on which patients depend for referrals, are aware of all the benefits of speech therapy regarding PD, and what percentage of patients is therefore actually referred to speech-language therapy assessments. The time of referral also varies. In Britain, a survey indicated that most people with PD are referred in the mid stages of the disease, whereas specialist speech-language therapists (SLTs) would prefer referral much earlier, at the diagnosis stage (Miller et al., 2011). Swallowing difficulties were reported as the single most common reason for referral, even though SLTs rated voice problems, poor intelligibility and self-reported problems nearly as important.

In Finland, the intensive and time-consuming LSVT LOUD is often not offered in its full extent due to scarcity of resources. Only approximately 70 Finnish speech-language therapists have the LSVT certification (Puhumalla paras!, 2018), although many more are familiar with the method and use some of the techniques when working with people with PD.

In order to gather some first-hand information about speech therapy received by people with PD, we approached by email seven speech-language therapists from Southern Finland (personal communications, November 2018). According to these SLTs, availability of speech therapy is largely dependent of the region. In bigger cities, people with PD are referred to speech therapy more

routinely, and the first visit is often at the time of diagnosis. At times, however, municipalities only refer people with PD to therapy after their speech and voice production is already notably impaired. Both individual and group therapy is offered, depending on the area, as is telephone counselling and therapy at a distance (including LSVT). The number of sessions is based on need. Rehabilitation may concentrate on voice, speech (dysarthria) or swallowing, or it may cover all three areas. Other themes mentioned were psychoeducation and cognitive exercises. Voice therapy methods used are typically LSVT and SpeakOut, or similar exercises. Voice amplifiers and Augmentative and Alternative Communication (AAC) are provided when needed.

In addition to speech therapy provided by public health care, The Finnish Parkinson Association organises intensive communication courses of varying lengths, where speech and voice rehabilitation is delivered by a multi-professional team. The number of applicants always surpasses the number of available places in the courses (The Finnish Parkinson Association's press release, September 28, 2018). Because of resource shortages, different kinds of group rehabilitation methods are of interest in health care. Internationally, previous research exists also on group singing interventions similar to the one investigated here.

1.4 Singing interventions in Parkinson's disease

1.4.1 Therapeutic application of singing

The therapeutic application of singing has been shown to have its place in the rehabilitation of various medical conditions, such as pulmonary diseases, mood disorders and aphasia (Kang, Scholp & Jiang, 2017, review). The mechanisms behind the benefits of singing are related to various physiological changes affecting, for instance, the cardiorespiratory system, neurotransmitters and hormones. Singing-related positive changes have been found to be, among other things, an improved immune function and an increase in happiness. Group singing has been shown to contribute positively also to the respiratory health and even the swallowing function of the healthy older adult population (Segall, 2017).

Voice-related changes in healthy voice-users have mainly been observed in the singing voice after singing training, and only rarely in the speaking voice (Mendes, Brown, Rothman & Sapienza, 2004; Siupsinskiene & Lycke, 2010). Nevertheless, evidence regarding people with Parkinson's disease and the benefit of singing does already exist across a wide range of speech and voice features (Barnish,

Atkinson, Barran & Barnish, 2016, see table 1), even though there is still only a limited quantity of research available on the possible health-related benefits of singing in Parkinson's disease. Also, the research has so far focused mainly on speech and voice, leaving wider psychosocial aspects, such as quality of life, with less attention.

Table 1. Outcome measures and results of singing intervention studies (modified according to Barnish et al., 2016).

First author	Outcome measures	Results
Di Benedetto (2009)	• Maximum phonation time (MPT) • Acoustic data from sustained vowel /ɑ/ • Quality of voice analysis, prosody and fatigue ratings	+ Improved quality of voice prosody and fatigue ratings for reading (not for monologue) + Increased MPT – No improvement in F_0, F_0 variation, jitter, shimmer, peak amplitude variation, F_0 tremor intensity or amplitude tremor intensity
Elefant (2012)	• Fluency and acoustic data from a read passage • Voice Handicap Index (VHI)	+ Improvement in the VHI physical subscale score – No improvement in VHI total score or functional and psychological subscales scores – No improvement in fluency or acoustic parameters (F_0, F_0 variation, SPL, SPL variation and voicing)
Evans (2012)	• Frenchay Dysarthria Assessment (FDA) • PDQ39 Quality of Life tool	+ Improvements in some aspects of the FDA – No change in any PDQ39 quality of life sub-scale scores
Haneishi (2001)	• Speech Intelligibility Inventory: Self-Assessment Form • Acoustic data from reading a passage	+ Improved SPL and carer-rated intelligibility + Some improvement in self-rated intelligibility and F_0 – No improvement in maximum duration and F_0 variability
Shih (2012)	• Acoustic data from reading a passage and a picture description • Voice Handicap Index (VHI) • Voice Related Quality of Life (VRQoL)	– No improvement in SPL, maximum cued volume, MPT, F_0, read speech pitch range or voicing contrast – No improvement in VHI or VRQoL
Tanner (2016)	• Acoustic data from spontaneous monologue • Acoustic data from reading a passage	+ Improved SPL range, F_0 and F_0 variation for read speech – No improvements in MPT, SPL of read speech, F_0 and F_0 variation of conversational speech
Yinger (2012)	• Acoustic data from reading a passage	+ Improved read speech SPL – No improvements for conversational speech SPL, F_0 or F_0 variability
Butala (2017)	• Loudness (dB) • Held vowel duration • Perturbance analysis • Patient-centered quality of life • Voice-related quality of life (VRQoL) • MDS-UPDRS scores • Montreal Cognitive Assessment • Subjective scales of depression, self-efficacy and overall well-being	+ Improved average SPL on the picture description + Improved minimal reading volumes (corresponding with decreased volume range) + Improvement on the MDS-UPDRS Motor scale regardless of intervention order (see table 2 for characteristics of the intervention)
Higgins (2018)	• Vowel space area (VSA) • Speech intelligibility	+ Increased mean VSA + Increased speech intelligibility

Han (2018)	• Maximum phonation time (MPT) • VHI • Geriatric Depression Scale (GDS) • Voice-Related Quality of Life (V-RQOL)	+ A statistically significant change in MPT + Decreased VHI and GDS + A significant change in the V-RQOL

In nine studies out of the ten presented above, there were statistically significant changes after a singing intervention in at least one variable examined (see table 1). Increased vocal intensity (SPL) or intensity range in reading a passage was rather a common finding, although these findings were not unequivocal across the studies. The same applies to the majority of the acoustic variables – some studies witnessed, for example, an increased maximum phonation time (MPT), whereas some did not. The psychosocial symptoms were also alleviated in some studies but not in all of them.

Despite the inconsistent nature of existing research, it is clear that therapeutic singing has the potential to benefit participants in many ways. There are reports that even some months after the intervention, participants have regarded their involvement in a singing group beneficial, fun, and engaging, and have appreciated especially the fellowship with other people with Parkinson's disease (Stegemöller et al., 2017). Taking part in a singing group has resulted in multiple benefits in many areas, including physical and cognitive functioning, mood, social connection and sense-of-self (Abell, Chalmers & Baird, 2017). Social connectedness, which brings about acceptance, validation, and emotional support to participants, has been an appreciated advantage of a therapeutic singing group. Other benefits, such as improved voice quality, raised energy levels, enhanced mood, increased self-confidence, and greater control over day-to-day activities have also been reported. However, there are some indications that group-singing-related improvements in well-being could be associated with the degree to which the participants feel integrated into the social group, which suggests that these effects could also be achieved with other kinds of group activities apart from singing (Pearce, Launay, Machin & Dunbar, 2016). To sum up, even though encouraging results have been obtained regarding both speech and voice production and psychosocial well-being, scientific research has not yet reached a full understanding of the benefits and mechanisms of singing and its possibilities in the rehabilitation setting.

1.4.2 Overview of research methods

The singing intervention studies on the PD population are rather heterogeneous in many respects. The studies have been considered rather limited in terms of sample sizes and study methods, regarding,

for example, control groups and participant randomization (Barnish et al., 2016, review; see table 2). Also, the outcome measures that have been used to report possible changes after singing interventions have varied from one study to another (see table 1 in the previous chapter).

Table 2. Characteristics of PD-related singing intervention studies (modified according to Barnish et al., 2016).

First author	*N*	Content	Duration
Di Benedetto (2009) *SGRMS*	20	• Performed in a group • Part A: Muscular relaxation and respiratory, laryngeal, oral and facial and prosodic exercises in preparation for singing • Part B: Choral singing (modified popular and liturgical chants) accompanied on the piano	Part A: 2 x 1 h / week 10 weeks Part B: 1 x 2 h / week 13 weeks **TOTAL 46h**
Elefant (2012) *SGRMS*	10	• Performed in a group • Introductory and closing conversation • Breathing, vocal and singing exercises (pop and folk songs) accompanied on the guitar	1 x 1 h / week 20 weeks **TOTAL 20 h**
Evans (2012) *SGRMS*	17	• Performed in a group • Physical and breathing exercises • Vibrant sound exercises including sirening • Call and response singing to well-known tunes • Singing songs	1 x 2 h / fortnight 2 years **TOTAL ~104h**
Haneishi (2001) *SGRMS*	4	• Performed individually • Opening and closing conversation • Warm-up and vocal exercises • Singing exercises • Sustained vowel production • Review and speech exercises	~ 3 x 1 h / week 12–14 sessions **TOTAL 12–14h**
Shih (2012) *SGRMS*	13	• Performed in a group • Physical and breathing exercises • Vocal warm-up • Singing popular songs	1 x 1,5 h / week 12 weeks **TOTAL 18h**
Tanner (2016) *SGRMS*	28	• Performed in a group • Vocal exercises • Melody and song singing (accompanied on the piano)	2 x 1,5 h / week 6 weeks **TOTAL 18h**
Yinger (2012) *SGRMS*	10	• Performed in a group • Opening and closing conversation • Physical warm-up and breathing exercises • Speech exercises and vocal warm-ups • Singing exercises (accompanied by guitar or keyboard)	2 x 50 minutes / week 6 weeks **TOTAL 10h**
Butala (2017) *RCCES*	26	• Participants first assigned to either a singing group or a facilitated discussion for 12 weeks • After 12 weeks, participants crossed over for an additional 12 weeks	2 x 12 weeks

Higgins (2018) *SGRMS*	10	• Performed in a group • Opening and closing conversations • A physical warm up and breathing exercises • Vocal exercises • Singing exercises	1 x 1,5h / week 11 weeks **TOTAL 16.5h**

Han (2018)
SGRMS
	8	• Performed individually at home or at a hospital
		• The sessions consisted of two aspects:
		  ○ Voice and emotion
		  ○ Song psychotherapy
			6 x 50 minutes / two weeks
			TOTAL 5h

SGRMS = Single group repeated measures study; RCCES = Randomized controlled comparative effectiveness study

Most of the aforementioned singing interventions have been implemented in a group setting, but there are some that were implemented individually. The interventions were led either by speech-language therapists with singing training or other professionals, such as music therapists or trained singers. The average number of participants was 15, and the mean age was 67 years. The duration and intensity varied noticeably. Most of the interventions included physical and vocal warm-up exercises followed by singing exercises or song-singing, sometimes accompanied on the piano or other musical instrument. The songs were chosen either by the participants or by the leader. Some interventions included more precise vocal exercises, such as vibrant sound exercises (e.g. sirening) or sustained vowel production. Speech exercises were also included in some interventions. Opening and closing conversations were rather typical of the sessions. In conclusion, these interventions seem to have had quite a lot in common despite the methodological differences between them. Of course, the similarities in the intervention descriptions do not necessarily mean that they were conducted the same way. Some of the factors that probably contributed to the results, such as the participants' integration into the social group, are rather impossible to describe in detail. Because of the various differences and methodological limitations, it is challenging to draw reliable conclusions from the current literature.

2 AIM OF THE STUDY AND RESEARCH QUESTIONS

This study forms part of a larger, multidisciplinary research project *Kuuluva ääni* ("Carrying voice") by Tampere University, which started in 2018 and will continue until 2021. The aim of the project is to obtain valuable information concerning the rehabilitation of voice and communication in Parkinson's disease and the possibilities of improving the quality of life of people with PD. The research proposal was approved by the Ethics Committee of the Tampere region (decision 25/2018).

The purpose of this study was to investigate the possible changes in the voice and voice-related psychosocial symptoms of individuals with Parkinson's disease following a group singing intervention. Research is needed to determine whether group singing could be a feasible addition to existing speech-language and voice therapy methods. The availability of therapy is already scarce in many places and will presumably be more so as the population ages and the number of people with PD increases accordingly. Furthermore, the methods that are used to treat voice problems associated with PD (LSVT, Speak out!) are especially demanding resource-wise: intensive as well as individual. Therefore, it is crucial to find more effective ways of using the resources and creating more intervention options both for service providers and patients. Group therapy methods, such as group singing, could provide alternative ways of offering people with PD more consistent and longer-lasting treatment periods in order to preserve their communication abilities for as long as possible.

The research questions were as follows:

1. Does the group singing intervention change the participants' voice-related psychosocial well-being as measured with the *Voice Handicap Index* (VHI) score?
2. Does the group singing intervention change the participants' voice production as measured with sound pressure level (SPL) and maximum phonation time (MPT)?
3. Does the group singing intervention change the participants' pitch and pitch variability as measured with F_0 and F_0 variation (SD)?

3 METHOD

3.1 Participants

Participants were recruited via local speech therapists and The Finnish Parkinson Association, including its local branch in Tampere. All participants signed a written consent form, and they were informed of the study's purpose and course before participating. They were also informed of the possibility of withdrawing from participation at any stage.

Eighteen individuals with idiopathic PD were randomly selected to the group singing intervention. The inclusion criterion was a diagnosis of idiopathic Parkinson's disease. The exclusion criteria were Deep Brain Stimulation (DBS) treatment, dementia, and communication disorders preceding the PD diagnosis (namely dysphonia, stuttering, aphasia, dysarthria and apraxia of speech). The severity of the participants' symptoms and the stage of disease progression were assessed using the Hoehn &

Yahr scale, with stage 0 indicating no signs of disease and stage 5 a very high level of disability. The participants' stages were between 1 and 4, average stage being 2. The level of possible cognitive impairment was measured using a Mini Mental Status Examination (MMSE). The MMSE scores range from 0 to 30 with lower values corresponding to a more severe cognitive impairment. Scores equal to or greater than 24 points indicate a normal cognition, whereas scores below 24 points can indicate cognitive impairment. All participants had a MMSE score higher than 24 (with the exception of one participant who only had a score of 21 but was included in the study nevertheless, given that his performance did not diverge from that of the others). Two participants abandoned the intervention before its end and were therefore excluded from this study.

Of the remaining 16 participants, 9 were male and 7 were female. The average age was 71 years, ranging from 53 to 82 years. The majority of the participants were retired. Time from diagnosis was on average 7 years, and it ranged from 1 to 18 years. Ten participants had received speech therapy previously. Four participants had had voice symptoms prior to the PD diagnosis. Before the intervention, the participants were asked to rate the self-perceived change in their speech after the onset of PD on a scale from 0 to 10 (0 = like before; 10 = very unclear). The average was 4, and the ratings ranged from 0 to 9. One participant reported a positive effect of medicine on speech, whereas the others reported no effect.

3.2 Intervention

The group singing intervention resembled traditional choir practice sessions, so that each session started with warm-up exercises followed by voice exercises and singing. The intervention was carried out by a BA student in music pedagogy with 20 years of experience in choir leading and theatre. She was assisted by a student in speech-language therapy and supervised by two experienced speech-language therapists and a professor of music studies. A number of student nurses were always present to assist the participants with practical matters. The intervention consisted of a 90-minute session once a week for 8 weeks, which were consecutive apart from a one-week break due to a public holiday. The group met at Tampere University in a class room, in which participants sat in a circle facing each other. During the exercises, the choir leader and/or the assistant often stood in the middle providing the participants with a visual cue to aid them with joining in.

The intervention was structured as follows:

1. Greetings, sharing experiences related to home exercises, and filling in a short questionnaire on emotional state and vocal status (pre-session)
2. Warm-up stretching and checking the posture
3. Vocal warm-up exercises
4. Singing exercises
5. Closing conversation and filling in a questionnaire on emotional state and vocal status (post-session)

The sessions were designed to target goals such as increased vocal loudness and kinaesthetic awareness (motor learning/muscle memory), which are similar to those of traditional, evidence-based speech and voice therapy methods used with people with PD, like LSVT LOUD. The main principle of LSVT LOUD is to increase vocal loudness through exercises that have a low cognitive load to make it easier for the participants to concentrate on their voice production. The singing intervention participants were urged to use loud voice and integrate big movements and different emotions to the voice production in order to intensify the singing exercises. They were also provided with exercise handouts and an audio CD and encouraged to practise regularly at home. Home practice was monitored through an exercise sheet filled in by the participants, and the choir leader also interviewed each participant briefly at the start of each session.

The aims of the singing intervention were further defined by the third session, according to clinicians' observations and participants' comments, to match more closely those of speech therapy (the aforementioned loud voice, big movements and low cognitive load). This was also emphasised to the participants, and the sessions were modified accordingly. For instance, the tempo of the exercises was slowed down, the choir leader spent less time behind the piano and provided instead more visual prompts facing the participants, and the lyrics of the songs were mostly interchanged for single vowels or syllables, such as *jaa* (ya:), which encourages a big jaw movement and opens the mouth wide. All this was done to reduce the cognitive load and to make concentrating on the voice production easier. The importance of practising regularly at home was also stressed increasingly towards the end of the intervention.

3.3 Data collection and outcome measures

This is a single group repeated measures study, in which possible voice changes occurring after a group singing intervention are examined combining acoustic and self-report measures. Audio

recordings were captured in quiet office rooms immediately prior to the beginning of the intervention and within two weeks after the last session, some exceptions notwithstanding. The pre-intervention self-report data was collected three months before the beginning of the intervention at the start of the project *Kuuluva ääni*, and the post-intervention self-report data in conjunction with the final audio recordings. All the recordings were made in WAV (Waveform Audio File) format, using Praat software (Boersma & Weenink, 6.0.37, 2018) and Focusrite audio interface. The headset microphone was maintained at a distance of 4 cm from the corner of the mouth, at an angle of 45 degrees. The recordings were calibrated for measuring voice SPL using a sound generator (BOSS TU-120, Roland Corporation, Los Angeles, CA) and a sound level meter (Tango, version 1.44, SINUS Messtechnik GmbH, Leipzig, Germany).

Reading and vowel prolongation provide useful information about speech characteristics, such as prosodic and phonatory abnormalities that are typical of Parkinson's disease (Duffy, 2005, p. 194). The vocal tasks the participants were asked to perform were:

1. Reading an excerpt from the passage *Pohjantuuli ja aurinko*
2. Three sustained phonations of the vowel /a/ for maximum duration

Participants were instructed to read the 18-word passage (*Pohjantuuli ja aurinko väittelivät, kummalla olisi enemmän voimaa, kun he samalla näkivät kulkijan, jolla oli yllään lämmin takki*) at a comfortable pitch and loudness in as natural a way as possible. Pauses were not removed from the reading sample before acoustic analysis, given that the participants acted as their own controls in this study and it could be assumed that their reading style would remain reasonably constant throughout the intervention. The three sustained phonations were also instructed to be produced at a comfortable pitch and loudness, in one deep breath and for as long as possible.

The acoustic measures captured from the reading of the passage were average sound pressure level (SPL) and fundamental frequency (F_0) with its variation (F_0 SD). The measures captured from the sustained phonation were maximum phonation time (MPT) and SPL. All acoustic measures were retrieved using Praat software version 5.3.82 (Boersma & Weenink, 2014).

Self-report data consisted of pre and post-intervention short-scale Voice Handicap Index (Jacobson et al., 1997; short-scale version by Nawka et al., 2009; Finnish translation by Alaluusua & Johansson, 2003; see appendix 1) questionnaires. They were used to assess the self-rated psychosocial impact of voice impairment. The international broad range short-scale VHI-9i is a 9-item questionnaire in which scores range from 0 to 36, with higher values indicating a more severe voice-related handicap.

Table 3. Short-scale Voice Handicap Index in English (Nawka et al., 2009).

		Never	Almost never	Some-times	Almost always	Always
		0	1	2	3	4
1	My voice makes it difficult for people to hear me. (F1)					
2	People have difficulty understanding me in a noisy room. (F3)					
3	The sound of my voice varies throughout the day. (P4)					
4	My family has difficulty hearing me, when I call them throughout the house. (F5)					
5	My voice difficulties restrict my personal and social life. (F16)					
6	The clarity of my voice is unpredictable. (P17)					
7	My voice is worse in the evening. (P21)					
8	I am less outgoing because of my voice problem. (E24)					
9	My voice makes me feel incompetent. (E29)					

The short-scale VHI has been found to approximate the complete VHI very well, although it has to be noted that the Finnish translation was not included in the item-reduction study conducted by Nawka et al. (2009). The full-scale VHI is considered a reliable and valid tool that can be recommended for use with people with PD (Guimaraes, Cardoso, Pinto & Ferreira, 2017). The use of the VHI-9i is justified, for example, when the subjectively experienced voice handicap is not the main target of the investigation (Nawka et al., 2009), which was the case in this study.

3.4 Statistical analysis

All statistical analysis were performed with PASW Statistics 18.0 software for Windows/Mac operating system (SPSS, Inc., Chicago, IL). Means and standard deviations were calculated for normally distributed variables. The differences between variables pre and post-intervention were analysed with Student's *t* test (paired samples) for the entire group. The subgroup F_0 analysis of males and females were performed with a nonparametric Wilcoxon Signed Ranks test. Statistical significance was indicated by $p \leq 0.05$. For some variables, it was also tested whether there were parallel changes between them. Possible similarities were analysed using Pearson Correlation Coefficient or the Spearman rank-order correlation coefficient**.**

Group level analysis of the Voice Handicap Index scores included data from all 16 participants. Average sound pressure level (SPL) and fundamental frequency (F_0) with its variation (F_0 SD) from

the reading of the passage were analysed on group level (N = 15; data from one participant was missing due to their not having attended the pre-intervention recordings). Maximum phonation time (MPT) and sound pressure level (SPL) from the sustained phonation were also analysed on group level (N = 14; two of the participants were not included due to missing or deviant data).

4 RESULTS

4.1 Short-scale Voice Handicap Index (VHI) score

The participants rated the psychosocial impact of their voice impairment as less severe after the intervention (p = .010, t = 2.93; 95% CI [0.78, 4.97]; see figure 1). The pre-intervention short-scale VHI scores ranged from 1 to 20 (mean 14 ± SD 6) and the post-intervention scores from 1 to 18 (mean 11 ± SD 5). On average, the scores improved by 3 points (± SD 4) after the intervention. The biggest improvement was 11 points. Four participants did not report any change in their self-perceived voice impairment. Two participants reported a minor change for the worse (1 and 2 points, respectively).

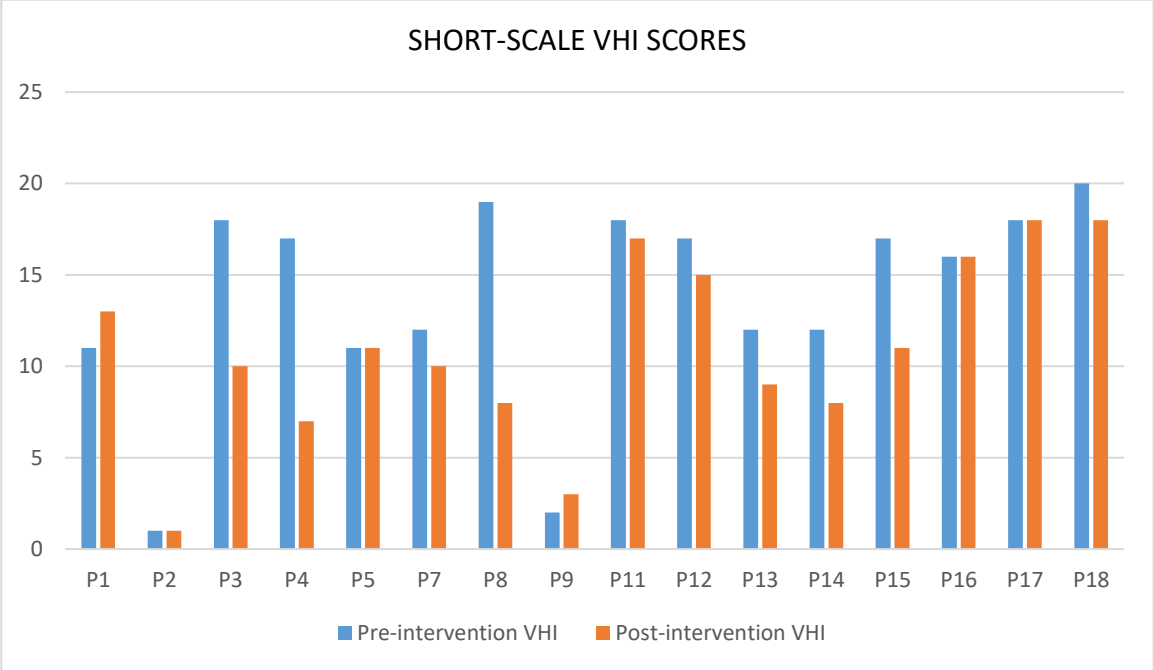

Figure 1. Pre and post-intervention short-scale VHI scores on a scale of 0 to 36 points. Higher values indicate a more severe voice-related handicap.

4.2 Sound pressure level (SPL) and maximum phonation time (MPT)

The participants produced a louder voice (SPL) after the intervention both in the reading task (p = .002, t = 3.90; 95% CI [-9.25, -2.68]) and in the sustained phonation (p = .005, t = -3.32; 95% CI, [-12.20, -2.59]; see table 4). The reading SPL ranged at baseline from 79.8 dB to 90.1 dB (mean 85.5 ± SD 3.8) and post-intervention from 81.7 dB to 100.1 dB (mean 91.4 ± SD 5.3). The sustained phonation SPL ranged at baseline from 75.4 dB to 97.2 dB (mean 86.2, ± SD 5.8) and post-intervention from 86.7 dB to 106.9 dB (mean 93.6 ± SD 5.6).

Table 4. Baseline and post-intervention sound pressure levels (dB).

SOUND PRESSURE LEVEL (SPL, dB)				
PARTICIPANT	SUSTAINED PHONATION /a/		ORAL READING	
	BASELINE	POST-INTERVENTION	BASELINE	POST-INTERVENTION
P1	80.3	97.4	80.9	97.9
P2	75.4	94.2	80.3	97.9
P3	81.4	97.9	81.9	92.3
P4	84.6	88.1	86.2	90.5
P5	81.1	87.6	79.8	85.8
P7	85.4	92.7	81.5	88.5
P8	92.0	92.5	84.7	86.9
P9	91.9	98.3	88.5	92.1
P11	89.9	106.9	90.0	100.1
P13	83.3	96.9	90.1	99.1
P14	97.2	86.7	90.0	91.7
P15	-	-	89.2	89.6
P16	87.8	90.2	88.2	88.1
P17	85.5	87.9	84.6	81.7
P18	91.1	93.3	88.7	89.7
MEAN (SD)	86.2 (6)	93.6 (6)	85.5 (4)	91.4 (5)

The participants' sound pressure level (SPL) increased on average 6.0 dB (± SD 5.9) in reading and 7.4 dB (± SD 8.3) in sustained phonation from baseline to post-intervention (see figure 2). The reading SPL improved at most by 17.6 dB and the sustained phonation SPL by 18.8 dB. There was no pre-post difference (change < 1 dB) in reading SPL for 1 participant and in sustained phonation SPL for 1 participant. The post-intervention reading SPL was lower for 1 participant and the sustained phonation SPL also for 1 participant.

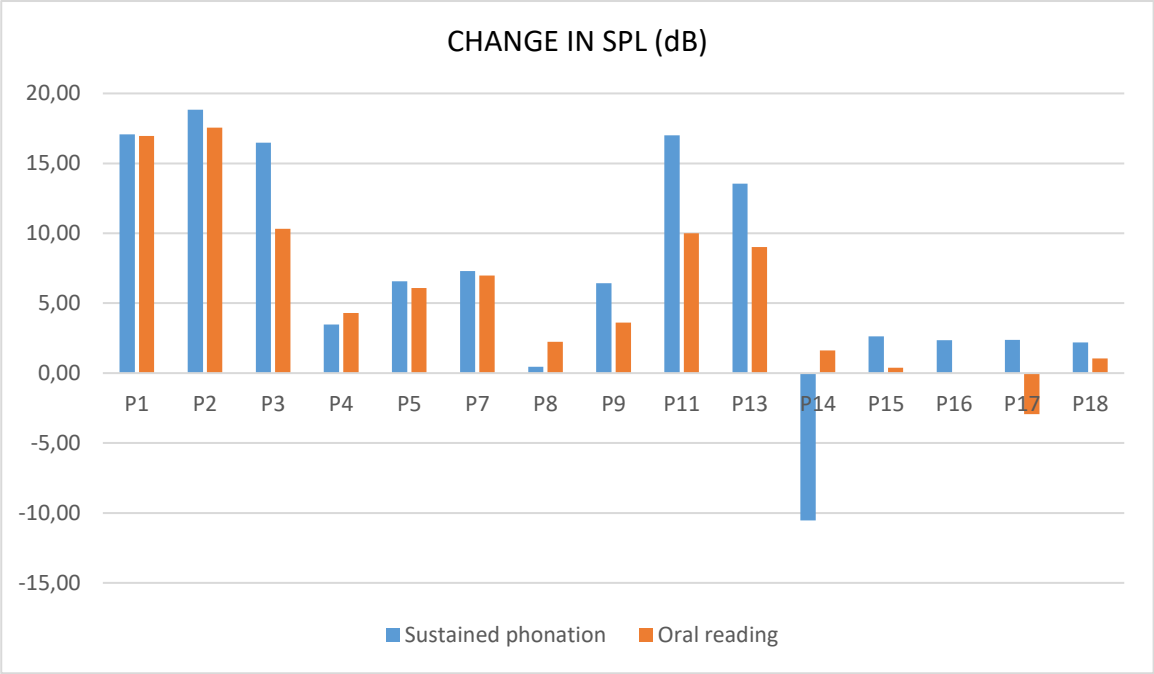

Figure 2. Baseline to post-intervention change in SPL.

The participants produced longer phonations (MPT) after the intervention (p = .011, t = -2.95; 95% CI [-3.89, -0.60]; see figure 3). The pre-intervention MPT ranged from 8.3 to 26.2 seconds (mean 14.5 ± SD 5.3) and post-intervention from 10.2 to 33.6 seconds (mean 16.8 ± SD 6.4). The MPT increased on average by 2 seconds (± SD 2.8). It increased at most by 7 seconds and decreased at most by 4 seconds. For 3 participants, no difference (change < 1 second) was detected.

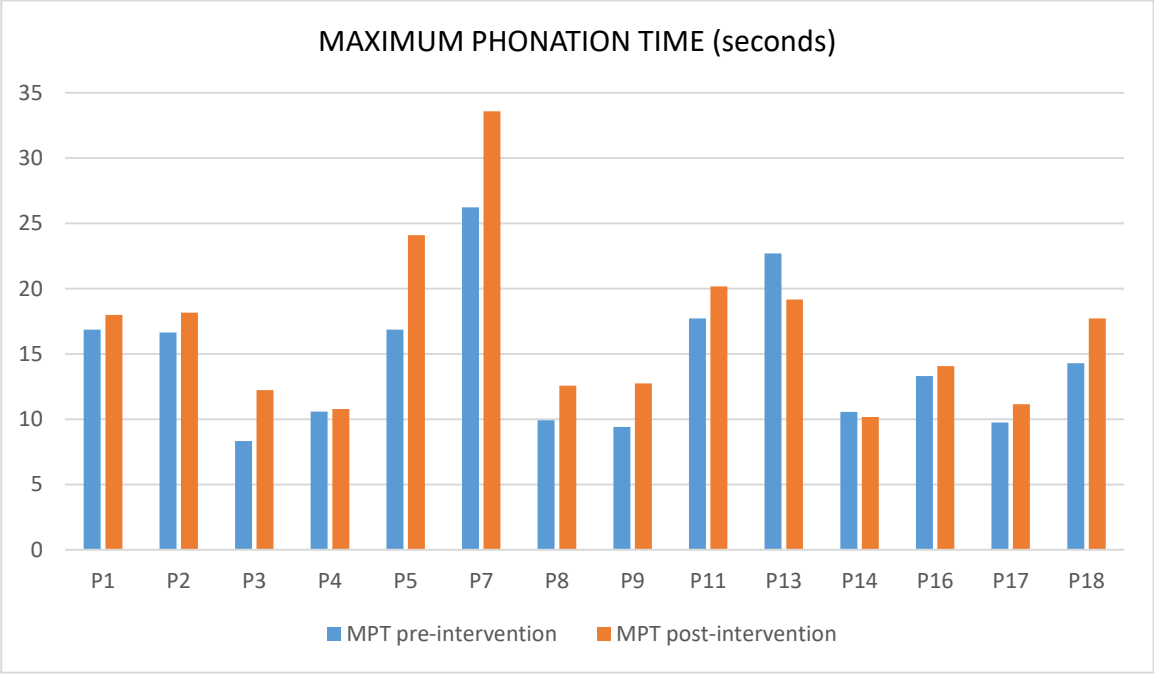

Figure 3. Pre and post-intervention MPT.

Most of the participants (79%) managed to increase or maintain the phonation time and to simultaneously produce a louder voice (see table 5). For one participant, the MPT decreased (-3.5 s.) while the SPL improved (+13.6 dB). For another, the MPT remained the same while there was a clear decrease in the SPL (-10.5 dB). Yet another participant's MPT increased (+2.6 s.) while there was no change in SPL.

Table 5. Changes in the phonation sound pressure level and maximum phonation times after the intervention.

PARTICIPANT	CHANGE IN SPL (dB)	CHANGE IN MPT (s.)
P1	17,1	1,1
P2	18,8	1,5
P3	16,5	3,9
P4	3,5	0,2
P5	6,6	7,2
P7	7,3	7,4
P8	0,5	2,6
P9	6,4	3,3
P11	17,0	2,5
P13	13,6	-3,5
P14	-10,5	-0,4
P16	2,4	0,8
P17	2,4	1,4
P18	2,2	3,4
MEAN (SD)	7,4	2,2

4.3 Fundamental frequency (F_0) and its variation (F_0 SD)

After the intervention, there was no significant change in the participants' fundamental frequency (F_0) in the reading task (($N = 15$, $p = .121$, $t = 1.65$; 95% CI [-1.33, 10.26]; see tables 6a and 6b). A subgroup analysis of males ($p = .483$) and females ($p = .344$) did not show a significant change, either.

The F_0 standard deviation (SD) from baseline to post-intervention showed no significant change ($N = 15$, $p = .411$, $t = .85$; 95% CI [-1.63, 3.77]; see tables 6a and 6b). The average baseline F_0 SD was 22 Hz (± SD 6) while the average post-intervention F_0 SD was 21 Hz (± SD 7). An F_0 SD subgroup analysis of males ($p = .204$) and females ($p = .916$) did not show a significant change.

Table 6a. Pre and post-intervention F_0 in reading (male participants).

PARTICIPANT	F_0 (Hz)			F_0 SD (Hz)	
	BASELINE	POST-INTERVENTION	CHANGE (semitones)	BASELINE	POST-INTERVENTION
P3	144	131	-2	20	14
P5	129	99	-6	16	8
P8	122	126	-	19	19
P11	127	134	-2	24	23
P13	140	144	+1	20	18
P15	132	133	-	16	13
P17	123	112	-2	14	15
P18	132	130	-	24	29
MEAN (SD)	131 (8)	126 (14)		19 (4)	17 (6)

Table 6b. Pre and post-intervention F_0 in reading (female participants).

PARTICIPANT	F_0 (Hz)			F_0 SD (Hz)	
	BASELINE	POST-INTERVENTION	CHANGE (semitones)	BASELINE	POST-INTERVENTION
P1	185	175	-1	24	24
P2	166	160	-1	24	26
P4	171	182	+1	19	27
P7	151	153	-	28	17
P9	176	162	-2	20	21
P14	225	215	-	40	36
P16	182	182	-	18	20
MEAN (SD)	179 (23)	176 (21)		25 (8)	24 (6)

However, some changes in individual performances before and after the intervention can be detected in the typical pitch (F_0) and pitch variability (F_0 SD). Two participants (P4, P13) used a slightly higher pitch in the post-intervention setting but nearly half of the participants experienced a drop (change ≥ 1 semitone) in F_0. One male participant (P5) even had a clear drop of six semitones. Three male participants (P3, P11, P17) had a drop of two semitones. For the female participants, one participant (P9) had a drop of two semitones. Two female participants (P1, P2) had a drop of one semitone.

While the pitch variability for the majority of the participants remained relatively constant, the results indicate that for some the variability changed somewhat. The biggest increase in pitch variability (F_0 SD) among the male participants was by 5 Hz (P18). The biggest drop in F_0 SD among the male participants was 8 Hz (P3). The biggest increase in F_0 SD among the female participants was 8 Hz (P4). The biggest drop in F_0 SD among the female participants was 11 Hz (P7).

4.4 Summary of the results

Most of the variables examined showed a statistically significant change in baseline to post-intervention measures (table 7). The VHI ratings improved, suggesting that the participants experienced less voice-related symptoms after the intervention. The participants produced longer phonations (MPT) and their sound pressure levels (SPL) were also higher in the post-intervention setting, indicating a stronger voice after the intervention. The changes in fundamental frequency (F_0) and its variation from baseline to post-intervention were not statistically significant, indicating that the participants' average reading pitch did not systematically rise or drop nor did the variability improve. The participants' individual performances were, however, rather wide-ranging in almost all the variables (see table 6 for mean differences and their standard deviations).

Table 7. Statistically significant changes in the measured variables.

Variable	**Mean difference**
Short-scale VHI	3 points (± SD 4)
SPL reading	6.0 dB (± SD 5.9)
SPL sustained phonation	7.4 dB (± SD 8.3)
MPT	2 seconds (± SD 2.8)

5 DISCUSSION

5.1 Examination of the results

5.1.1 Short-scale Voice Handicap Index (VHI)

After the intervention, the participants rated the psychosocial impact of their voice impairment as less severe. This is a very central finding since there are few earlier indications of group singing related changes in a self-perceived voice handicap. In a very recent study by Han et al. (2018), a significant improvement in the full VHI scores was, however, detected after a singing intervention. And in an earlier study by Elefant et al. (2012), which included an examination of a full-scale VHI, a significant change for the better in the physical subscale of the VHI was also observed after 20 weeks of group singing intervention. In the other two subscales (functional and emotional) or in the full-scale VHI as a whole no significant change was detected, although a slight improvement in scores was reported in

these measures. Given that in the present study a short-scale version of VHI was used, the earlier results do not, however, entirely lend themselves to comparison.

In the present study, changes in short-scale VHI did not correlate with changes in SPL in the sustained phonation and reading task, respectively (r_s = .460, p = .098 / r_s = .207, p = .458). The participants who achieved the greatest improvements in their VHI scores were not the ones who gained the biggest increases in SPL, which is interesting, given that weak voice is considered to be a very debilitating symptom in activities of daily living (Theodoros, 2011). This result may be explained by the fact that speech and voice impairments as such are not of great concern to people with PD (Miller et al., 2006; van Uem et al., 2016). Instead, they worry about the impact of these changes on their self-concept, family dynamics, and their ability to participate in everyday activities (Miller et al., 2006). Since voice and speech problems were not equally relevant to all participants, some may have been less inclined to do voice exercises and practice intensively at home. Despite this, they may have gained a psychosocial benefit from the intervention. Therefore, it is possible that some people may have experienced a clear change for the better in their voice-related psychosocial well-being even if the changes are not reflected in the acoustic measures. Although acoustic measures are central to voice-related intervention studies, the psychosocial benefits should also be acknowledged, considering that psychosocial functioning deficits that result in participation restrictions are bound to have a strong negative effect on quality of life (van Uem et al., 2016).

5.1.2 Sound pressure level (SPL) and maximum phonation time (MPT)

After the intervention, the participants systematically used a louder voice both in the reading task and sustained phonation. An increase in SPL following a singing intervention has been detected also in some earlier studies (see e.g. Butala et al., 2017; Haneishi, 2001; Yinger & Lapointe, 2012) even though some contradictory results have also been presented (see e.g. Elefant, Baker, Lotan, Lagesen, & Skeie, 2012; Tanner, Rammage & Liu, 2016). Based on the results of the current study, increased SPL in sustained phonation was strongly related to increased SPL in the reading task (N = 14, r = .83, p < .0005). Thus, the participants whose SPL increased during sustained phonation also experienced an increase in the reading task. Because the participants produced both vocal tasks on a similar intensity level, this could indicate an authentic change in vocal intensity. There was, however, a slight difference in the average intensity change between the two tasks. The change in sustained phonation was on average 7.4 dB, while that of the reading task was 6.0 dB. The difference could be explained at least partly by the pauses, which were not removed from the reading samples and which may have

caused a decrease in the average SPL. The average increases are in any case consistent with earlier research on LSVT-based interventions both in individual and group settings (Ramig et al., 2001; Searl et al., 2011). An increase of ~6 dB in SPL can be interpreted as a promising result, considering that people with PD have been found to have a vocal SPL that is on average 2–4 dB lower (measured at 30 cm) than that of healthy comparisons (Fox & Ramig, 1997). Since this decrease of only 2–4 dB corresponds to a 40% loudness reduction perceptually and as a result affects intelligibility, an increase of ~6 dB is bound to improve it.

The statistically significant improvement in average SPL may be explained by an improvement in the respiratory function and vocal fold closure, which are often compromised in Parkinson's disease, causing a difficulty in producing a strong loud voice (Hammer & Barlow, 2010). This suggests that the production of a louder voice post-treatment could be due to more exact and better controlled movement in voice-related musculature. Because of the nature of this intervention, which did not directly target the self-monitoring and awareness of voice intensity like LSVT LOUD does, it can be hypothesised that the change is more linked to improved cooperation of respiratory and vocal fold function. This assumption is supported by the fact that the intervention included a number of exercises that concentrated on breathing, posture and warm-up of both body and voice. However, it is also possible that improved internal calibration occurred even though personal feedback concerning loudness was scarce – sound level metres were not routinely used, for example. This was, of course, due to the large number of participants in the group. Therefore, it is possible that there were participants in the group who thought they were producing a loud voice but were in fact not, because of their impaired self-monitoring. The production of a loud voice was also not the only aim of the intervention, unlike in LSVT LOUD. In any case, it is interesting that there was a clear improvement in average SPL despite these differences.

Regarding the maximum phonation time (MPT), the participants produced significantly longer phonations in the post-intervention sustained phonation task than in the baseline setting. This finding is in concordance with some earlier studies on singing interventions (Di Benedetto et al., 2009; Han et al., 2018), although a significant improvement in MPT has not occurred in every study including this variable (see, for example, Haneishi, 2001; Shih et al., 2012; Tanner et al., 2016). In the present study, the majority of the participants were able to produce phonations that were longer as well as louder. This is interesting, because according to Hirano and Kent et al. (as cited in Tanner et al., 2016), louder phonation is associated with higher phonation flow rates and with shorter phonation time.

The statistically significant improvement in both SPL and MPT could be interpreted as further proof of an authentic change for better in vocal intensity, perhaps due to an improved vocal fold closure. However, it is important to remember that a change detected in a clinical setting and in certain types of speech and voice tasks does not necessarily mean that this carries over to the activities of daily living. In their daily lives, people with PD have to rely on spontaneous, conversational speech, in which the reduced loudness tends to be the most evident (Moon, Adams & Jog, 2006) and in which achieving a consistent change is probably the most challenging.

5.1.3 Fundamental frequency (F_0) and its variation (F_0 SD)

After the intervention, no significant change was detected in the average fundamental frequency (F_0) and its standard deviation (F_0 SD). For the majority of the participants, the difference between the baseline and post-intervention fundamental frequencies corresponded to a 0–2 semitone change. Only one participant had a clear decrease of 6 semitones in their average reading pitch, which could be a sign of the disease advancing. However, the fact that there was no significant change in the average fundamental frequency indicates that the participants did not raise their vocal intensity level (SPL) by raising their average F_0. This is interesting, since according to Seikel (as cited in Haneishi, 2001), fundamental frequency has a tendency to increase with vocal intensity because the two variables are linked to the same mechanism. This finding could also support the interpretation that the louder post-intervention voice could be due to an improved functioning and control of the respiratory and vocal fold function.

The fact that there was no significant change in the average F_0 after the singing intervention indicates also that there was no change in the possible monotone quality of the participants' voices. The findings in earlier PD-related singing intervention studies regarding F_0 are diverse – some have demonstrated changes in F_0 and its variation (see e.g. Haneishi, 2001; Tanner, 2016) while others have not (see e.g. Di Benedetto et al., 2009; Shih et al., 2012). The lowest possible F_0 of people with Parkinson has been found to be higher than that of healthy controls, which in turn makes the maximum phonational frequency range (MPFR) more limited than usual (Baken & Orlikoff, 2000, pp. 187–189). For this reason, it could be hypothesised that a drop of 1–2 semitones experienced by nearly half of the participants is a clinically relevant finding, since it could indicate that the participants' frequency range was, in fact, wider after the intervention.

It has to be noted, however, that the perceived monotony of pitch is tied to the complex phenomenon of dysprosody, where stress and intonation patterns disappear or become altered (Duffy, 2005, p. 196; Miller, 2017). As a whole, dysprosody is a generalised higher-level impairment involving both language production and comprehension, which makes it difficult to measure in its entirety, especially using only acoustic measures. In other words, a mere before and after examination of the average F_0 together with its standard deviation may not provide enough information on the possible changes in the prosodic features. In the case of the current study, the absence of a listener panel and reference values (F_0 / F_0 SD) collected from healthy, age-matched Finnish speaking peers made it challenging to draw a reliable conclusion from the results. Since limited pitch variability can be present already in the early stages of PD (Holmes et al., 2000), the absence of reference values made it impossible to estimate if the participants' average fundamental frequency and its standard deviation had been affected by dysprosody, or whether there had been no change in this respect.

5.2 Methodological considerations

5.2.1 Participants and intervention

The participants were recruited on a voluntary basis: information about the project was forwarded to associations and speech-language therapists, and those interested contacted the university. The upside of this arrangement was that the participants were in general very motivated: the attendance was good overall, and the number of people abandoning the intervention was low. The downside is that this way, it is possible that the participants were not representative of the entire population with PD, as those in poorer condition, physically or mentally, probably did not sign up.

A total of 16 participants completed the intervention, which is quite close to the average sample size of 15 participants of previous singing intervention studies (see chapter 1.4.1). However, voice samples for all the participants were not available for examination due to unexpected scheduling and technical matters. This reduced the number of participants to 14 at its lowest, depending on the variable analysed. The participants were on average 71 years old, compared with the average age of 67 years of the previous studies. Before the intervention, only one participant reported a positive effect of medication on speech, and during the intervention no changes in the participants' anti-parkinsonian medication were reported. This suggests that the results of this study were not compromised by effects of medication.

The total duration of the intervention was 12 hours (8 x 90 minutes), compared with an approximate average of 20 hours of previous studies (see chapter 1.4.1). The sessions were organised once a week, which seems to be quite a typical arrangement, as in previous interventions the participants also met once or twice a week. The session duration of 90 minutes is also rather an average length for a singing intervention. In the current study, the intervention was carried out by a professional choir leader (albeit a student), with two experienced speech-language therapists targeting rehabilitation goals and supervising the sessions. In previous studies, it has been quite typical that the leader has been either a professional singer/singing instructor, a music therapist and/or a speech-language therapist. Given that in group interventions the focus is always also on the group dynamics and general atmosphere – which can be an encouraging and enabling environment for exercising and having fun – the leader's expertise in choir leading, together with her charisma and personal interest in PD, may have been one of the strengths of this intervention. Since many participants had mobility limitations, the presence of the student nurses helped to keep the sessions accessible for all, which may also have had a favourable effect on the group dynamics.

The structure of the intervention followed more or less the general outlines of earlier singing interventions (see table 2) with its conversational elements, physical and vocal warm-ups, exercises supporting respiratory function, and song singing. Furthermore, however, the aims of the singing intervention were defined to target similar goals as in evidence-based speech and voice therapy, including vocal loudness and integration of big movements.

The intervention was a pilot, which entailed creating an entirely new model of treatment and merging elements of traditional methods, such as LSVT LOUD, into singing pedagogics. Because the concept was constantly developed further, out of the eight sessions perhaps five could be fully exploited. In the future, there could perhaps be a short period of traditional speech-language therapy first (LSVT-type sessions, for example), to prime the participants for the singing intervention, so that the principles of voice production would be clear to them from the start (cf. Di Benedetto et al., 2009). Once the basic principles have been assimilated, singing can be a good way of achieving enough repetitions (Shih et al., 2012). Because singing is a creative activity, people may also find it more motivating than mere voice exercises.

In this kind of intervention, the participants use their voices more consistently and for longer periods of time than in traditional speech therapy. Singing also involves a great deal of muscle work in an amusing, fun way, and emotions and creative expression can also be employed. The support of the group is an added factor, too. The results suggest all this can improve the mood and general well-

being of people with PD, in addition to having a positive influence on their voice. This was supported by both the short-scale VHI scores and anecdotal reports.

The intervention lasted only eight weeks, with a weekly 90-minute session. In many earlier studies, group singing interventions of this intensity and frequency have not brought about much change (see e.g. Shih et al., 2012). In the current study, in addition to the weekly sessions, the participants were encouraged to practice at home, but data on whether they did and how much is based solely on self-reports. It is possible, in any case, that regular home exercises raised the intensity of the intervention to a sufficient level (according to anecdotal reports, many participants found the exercise CD very helpful in achieving regular repetitions). As part of the *Kuuluva ääni* project, follow-up recordings will be made for up to two years after the intervention, which may further motivate the participants to keep up practicing at home. The follow-ups should provide interesting information about the permanence of the achieved results, even though interpreting it may be challenging due to the progressive nature of the disease and the lack of a control group. Because there was no control group in this study, it is impossible to determine what caused the changes in the voices of the participants and in their psychosocial self-reports – whether it was the voice exercises, singing, having a weekly "hobby" with like-minded individuals, home exercises, the choir leader's charismatic approach to practicing, or something else altogether. Also, it has to be taken into account that the participants other activities at the time of the intervention were not controlled: there were some who attended other choirs apart from this one, for example.

5.2.2 Data collection and outcome measures

Because this was a single group repeated measures study as opposed to a controlled comparative effectiveness study, we could only examine the change occurring after intervention instead of the effects of the intervention. In order to capture the change as accurately as possible, we used what was in fact baseline 3, which was collected immediately prior to the intervention. Baseline 1 and 2 had been collected roughly two months earlier at the very beginning of the research project *Kuuluva ääni*. Considering that PD is a progressive disease, we deemed the baseline 3 the most appropriate, even though the baseline 3 measurements included only a shorter reading sample and no short-scale VHI. We decided to use the shorter reading samples and to include the short-scale VHI from baseline 1.

The self-report data consisted of the baseline and post-intervention short-scale Voice Handicap Index scores, and a significant change was detected after the intervention. The short-scale VHI does not

lend itself to subscale analysis, whereas the full version VHI would have provided more detailed information on the voice-related handicap. However, the short-scale VHI has been found to approximate the complete VHI very well (*Nawka et al., 2009)* and is rather quick and easy to fill in, which can be considered an advantage when assessing people with Parkinson's disease.

The recordings were made with a headset microphone at a distance of 4 cm from the corner of the mouth, in order to better control the distance between the mouth and the microphone even in the case of the participant moving their head or changing their posture. In the end, it might have been preferable to use either a fixed microphone at a distance of 30 cm or a combination of the two. The headset microphone is very sensitive to even slight differences in the distance and/or the angle in relation to the mouth. In practice, it was thus challenging to ascertain that the microphone was equidistant with all the participants. For practical reasons, both the baseline and post-intervention recordings were made using various combinations of laptop computers, sound cards and microphones. Because of this, all the combinations were duly calibrated for the measures to be comparable. However, using the same equipment for all the participants would of course have been ideal.

Regarding the voice tasks, the reading sample in baseline 3 was short, only 18 words. It is possible that a longer sample would have shown more variation. Even though F_0 together with F_0 SD is considered a valid way of assessing the monotone quality of a voice or the possible change in it (Baken & Orlikoff, 2000, p. 170), it is not entirely clear if these outcome measures adequately bring out the monotony with such a short sample. Apart from the acoustic measures, then, it would perhaps be useful to have a panel of listeners do a perceptual evaluation of the voice and speech samples. Miller (2017) suggests using specifically designed sentences to evaluate stress and intonation patterns through listeners' perceptual judgements. Monotone quality is in its entirety difficult to capture with just few acoustic measures, so adding a perceptual analysis would have given a fuller picture of the phenomenon. One further possibility to analyse the monotony of pitch would have been through a maximum phonation frequency range (MPFR), which would have given the lowest and highest possible F_0, and for which there would have been some reference values, albeit for English speakers (see Baken & Orlikoff, 2000, p. 189). Regarding the sustained phonations, the longest of three samples was measured for the maximum phonation time instead of the average, because it reflected the maximum capacity of a participant more reliably than the average of all samples.

The acoustic measures used in this study (SPL, MPT, F_0, F_0 SD) were largely consistent with existing voice intervention studies. For this reason, the same short-comings also apply. As Adams and Dykstra

(2009, p. 168) and Theodoros (2011) have pointed out, even if the study yields results in the form of positive changes in SPL, this indicates only that the participants are able to use the louder voice in certain tasks and in the context of a speech clinic, which is an unnatural environment and differs a great deal from their normal daily surroundings. Therefore, in order to capture the real habituation, participants would need to be observed perceptually and their voices measured acoustically in a more natural environment. The assessment should also include various types of voice tasks (Theodoros, 2011). It is known that spontaneous, conversational speech is where the reduced loudness is usually most evident in PD (Moon, Adams & Jog, 2006), so it would be interesting to assess that in connection with activities of daily living. An array of tasks would of course give an even more comprehensive picture of the impairment and changes therein. In this study, SPL was analysed from a reading sample and from sustained phonation. There was a correlation between the changes in the two, which could indicate that the tasks were relevant in that they brought out the change in a consistent way.

Due to the progressive nature of the disease, it would be important to gather voice information starting at the time the disease is first suspected so that any change could be compared with earlier data. In the future, we hope this could be done with a portable, user-friendly technical application utilising an algorithm based on reference values both from the healthy population and people with Parkinson's disease. With this device, the users could receive bio-feedback about their voice (e.g. loudness, monotone quality), which could help them modify their voice use accordingly. Consequently, people could serve as their own controls as the disease progresses and could, at the same time, help to collect data on the progression of voice symptoms in PD for the purposes of scientific research.

5.3 Clinical implications and future research

The purpose of this study was to investigate the possible changes in the voice and voice-related psychosocial symptoms of individuals with Parkinson's disease following a group singing intervention. The findings suggest that a group singing intervention is a potentially beneficial addition to more traditional methods of voice rehabilitation in Parkinson's disease. Group singing interventions could be a quality-of-life improving and cost-effective way of offering voice treatment to people with Parkinson's disease. As the population ages, treatment and rehabilitation require more and more resources, which in the field of adult speech-language therapy are already scarce. These new interventions might widen the possibilities of rehabilitation and ultimately lead to a change in the care guidelines. The group singing intervention is seen here as a complementary therapy approach to be used alongside traditional voice and speech therapy, especially in the earlier stages of the

disease. Regular singing exercises might postpone the need for individual speech therapy in PD and help preserve communicative abilities for as long as possible.

Doing voice and singing exercises in a group setting improved some vocal skills, but whether those skills transfer to daily living remains unclear at this point. It is possible that for the skills to be transferred to the everyday life participants would require a longer treatment period, from both the vocal and psychosocial points of view. Even though group interventions have their benefits, the needs of people with Parkinson's disease remain varied and need to be addressed on a personal basis. Some need more practice and attention than others, and would therefore also require more individual, one-on-one therapy in addition to the group sessions. The individual sessions could also serve as an introduction to group therapy or vice versa, and the skills acquired in individual therapy could perhaps be preserved better if the one-on-one treatment period was followed by a group singing period. Group sessions could also be offered alone, if individual therapy is not available. Some practice is always better than no practice.

Group singing gives people with PD an opportunity to widen their social circles and create networks. Simply getting out of the house and doing something fun with other people at a regular basis is a revelation for many. An improvement in the mood and activity levels may well lead to increased motivation and make people more eager to practice their vocal skills. It has indeed been suggested that speech treatment for people with PD should focus more on the psychosocial aspects of communication along with the goals having to do directly with voice or speech (Yorkston et al., 2017). The results of this study suggest that a combination of the two may well be beneficial and worth considering clinically.

Regarding further studies, it would be important to study the changes achieved in a group singing intervention with a control group, in order to ascertain the effect of the intervention. It would also be interesting to study whether a group singing intervention of this intensity also has an effect on respiratory health and swallowing. Regarding the methodological choices, due to the nature of the disease, it would be interesting to examine the tendencies of the progression of the participants' voice and speech symptoms before the intervention. In the case of people with degenerative diseases, no change can often be considered a positive result. This is in keeping with the notion of the importance of speech-language treatment in maintaining people's communicative abilities and, consequently, quality of life for as long as possible.

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APPENDIX 1: Short-scale Voice Handicap Index (VHI) questionnaire in Finnish
(Jacobson et al., 1997; Finnish translation by Alaluusua & Johansson, 2003; Short-scale version by Nawka et al., 2009)

Äänioirekysely (Voice Handicap Index9)

Näillä väittämillä monet ihmiset ovat kuivailleet omaa ääntään ja sen vaikutuksia elämäänsä. Laita rasti sen vaihtoehdon kohdalle, joka kertoo, kuinka usein sinusta tuntuu samalta.

Nimi_____

Päivämäärä_____

		Ei koskaan	Ei juuri koskaan	Joskus	Melkein aina	Aina
		0	1	2	3	4
1	Ääneni vuoksi ihmisten on vaikea kuulla minua. (T1)					
2	Meluisassa ympäristössä ihmisten on vaikea ymmärtää, mitä sanon. (T2)					
3	Ääneni laatu vaihtelee päivän mittaan. (F2)					
4	Puheeni ei kuulu kauas, esim. perheeni jäsenten on vaikea kuulla minua, kun kutsun heitä toiselta puolelta taloa. (T3)					
5	Äänivaikeudet rajoittavat henkilökohtaista ja sosiaalista elämääni. (T8)					
6	Ääneni selkeyttä on vaikea ennustaa. (F6)					
7	Ääneni on illalla huonompi. (F9)					
8	Ääniongelmani vuoksi en ole yhtä ulospäin suuntautunut kuin aiemmin. (E5)					
9	Ääneni vuoksi tunnen itseni epäpäteväksi. (E9)					

Pisteet yhteensä_____

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